

(C) AMENDMENTS TO THE CLAIMS

1. (Currently amended) A method for deghosting and water surface multiple reflection attenuation in dual sensor marine seismic data, comprising:

transforming data acquired at each of a plurality of source positions by the spatial Fourier transform into the spatial Fourier domain;

decomposing the transformed data into upgoing and downgoing wavefield components using a measured parameter related to pressure and measured parameter related to vertical particle motion; and

determining a substantially multiple-free wavefield from the decomposed wavefield components ~~independently of knowledge of a source wavelet~~, by solving a system of equations for measured total wavefield and measured multiple free wavefield at the plurality of source positions.

2. (Original) The method of claim 1 wherein the data are acquired at a plurality of spaced apart locations at a selected depth below the water surface using a dual sensor streamer.

3. (Original) The method of claim 2 wherein the selected depth is below a depth of a seismic energy source.

4. (Original) The method of claim 1 wherein the data are acquired using an ocean bottom cable.

5. (Original) The method of claim 1 wherein the parameter related to pressure comprises change in pressure with respect to time.

6. (Original) The method of claim 1 wherein the parameter related to vertical particle motion comprises particle velocity.

7. (Original) The method of claim 1 wherein the parameter related to vertical particle motion comprises the particle acceleration.

8. (Canceled)

8. (Original) The method of claim 1 wherein the determining the substantially multiple free wavefield comprises solving a system of equations for measured total wavefield and measured multiple free wavefield at the plurality of source positions.

9. (Original) The method of claim 1 further comprising determining a source wavelet from the decomposed wavefield components.

10 – 15. (Canceled)

16. (Currently amended) A method for seismic exploration, comprising:
actuating a seismic energy source in a body of water at a plurality of positions;
measuring a parameter related to pressure at a plurality of locations at a selected depth below the surface of the body of water;
measuring a parameter related to a vertical component of particle motion at substantially the same locations as measuring the parameter related to pressure;
transforming the measurements acquired at each of a plurality of source positions by the spatial Fourier transform into the spatial Fourier domain;
decomposing the transformed measurements of the pressure related parameter and particle motion parameter into upgoing and downgoing wavefield components;
and
determining a substantially multiple-free wavefield from the decomposed wavefield components independently of knowledge of a source wavelet.
determining a substantially multiple-free wavefield from the decomposed wavefield components ~~independently of knowledge of a source wavelet~~, by solving a system of equations for measured total wavefield and measured multiple free wavefield at the plurality of source positions.

17. (Original) The method of claim 16 wherein the selected depth is below a depth at which the seismic energy source is actuated.

18. (Original) The method of claim 16 wherein the parameter related to pressure comprises change in pressure with respect to time.

19. (Original) The method of claim 16 wherein the parameter related to vertical particle motion comprises particle velocity.

20. (Original) The method of claim 16 wherein the parameter related to vertical particle motion comprises the particle acceleration.

21. (Canceled)

22. (Previously presented) The method of claim 16 wherein the decomposing comprises:

transforming the data into the spatial Fourier domain;

separating an upgoing wavefield component of the transformed data in the spatial Fourier domain; and

inverse transforming the upgoing component into the spatial frequency domain.

23. (Original) The method of claim 16 further comprising determining a source wavelet from the decomposed wavefield components.

24. (Original) The method of claim 16 wherein the data are acquired using a dual sensor streamer.

25. (Original) The method of claim 16 wherein the data are acquired using an ocean bottom cable.

26. (Currently amended) A computer program stored in a computer readable medium, the program containing logic operable to cause a programmable computer to perform steps comprising:

transforming seismic signals acquired at each of a plurality of seismic energy source positions by the spatial Fourier transform into the spatial Fourier domain;

decomposing the transformed seismic signals into upgoing and downgoing wavefield components using a measured parameter related to pressure and measured parameter related to vertical particle motion; and

determining a substantially multiple-free wavefield from the decomposed wavefield components independently of knowledge of a source wavelet.

determining a substantially multiple-free wavefield from the decomposed wavefield components ~~independently of knowledge of a source wavelet~~, by solving a system of equations for measured total wavefield and measured multiple free wavefield at the plurality of source positions.

27. (Original) The program of claim 26 wherein the seismic signals are acquired at a plurality of spaced apart locations at a selected depth below a water surface.

28. (Original) The program of claim 26 wherein the selected depth is below a depth at which a seismic energy source is disposed.

29. (Original) The program of claim 26 wherein the parameter related to pressure comprises change in pressure with respect to time.

30. (Original) The program of claim 26 wherein the parameter related to vertical particle motion comprises particle velocity.

31. (Original) The program of claim 26 wherein the parameter related to vertical particle motion comprises the particle acceleration.

32. (Canceled)

33. (Currently amended) A method for seismic exploration, comprising:
towing at least one seismic energy source in a body of water;
towing at least one seismic streamer at a selected depth in the body of water, the streamer
having a plurality of sensor sets thereon, each of the plurality of sensor sets
having thereon a first sensor adapted to measure a parameter related to pressure of
the water and a second sensor adapted to measure a parameter related to a vertical
component of particle motion at substantially the same locations as first sensor;
actuating the seismic energy source at a plurality of positions in the water;
measuring signals generated by each of the first and second sensors in the sensor sets in
response to each of the actuations of the source;
transforming the measurements acquired at each of the plurality of source positions by
the spatial Fourier transform into the spatial Fourier domain;
decomposing the transformed measurements of the pressure related parameter and
particle motion parameter into upgoing and downgoing wavefield components;
and
determining a substantially multiple-free wavefield from the decomposed wavefield
components independently of knowledge of a source wavelet.
determining a substantially multiple-free wavefield from the decomposed wavefield
components ~~independently of knowledge of a source wavelet~~, by solving a system
of equations for measured total wavefield and measured multiple free wavefield at
the plurality of source positions.

34. (Original) The method of claim 33 wherein the selected depth is below a
depth at which the seismic energy source is actuated.

35. (Original) The method of claim 33 wherein the parameter related to pressure
comprises change in pressure with respect to time.

36. (Original) The method of claim 33 wherein the parameter related to vertical
particle motion comprises particle velocity.

37. (Original) The method of claim 33 wherein the parameter related to vertical particle motion comprises the particle acceleration.

38. (Canceled)

39. (Previously presented) The method of claim 33 wherein the decomposing comprises transforming the measurements into the spatial Fourier domain and separating the upgoing and downgoing wavefield components in the transformed measurements.

40. (Previously presented) The method of claim 33 further comprising:
deploying at least one ocean bottom cable having a plurality of substantially collocated sensor pairs at spaced apart positions thereon, the sensor pairs including a sensor responsive to a parameter related to pressure and a sensor responsive to particle motion;
measuring signals generated by each of the sensors in the sensor pairs in response to each of the actuations of the source;
decomposing the measurements of the pressure related parameter and particle motion parameter acquired at each of the plurality of source positions into upgoing and downgoing wavefield components; and
determining a substantially multiple-free wavefield from the decomposed wavefield components independently of knowledge of a source wavelet.

41 - 42. (Canceled)